The ISL6224 provides power control and protection for a single, adjustable output voltage required to power chip-sets and memory banks in high-performance notebooks and PDAs. This output voltage is adjustable in the range from 0.9V to 5.5V. The MOSFET driver, output voltage and current monitoring and protection circuitry are included in a single 16 lead SSOP package.

The synchronous buck converter can be configured for either 300kHz or 600kHz switching frequencies. When operated from battery voltages ranging from 4V to 24V, a switching frequency of 300kHz is recommended. When operating from 5V, switching frequencies of 300kHz or 600kHz are an option. The output filter size is futher reduced when operating at 600kHz.

The ISL6224 and the evaluation board reference design provide an efficient, cost effective and compact solution for notebooks, PDAs and other portable equipment. Synchronous rectification and hysteretic operation at light loads contribute to a high efficiency over a wide range of input voltages and loads. Efficiency is further enhanced by using MOSFETs $R_{DS(ON)}$ as a current sense component. Feed-forward ramp modulation, average current mode control and internal feed-back compensation provide fast and firm handling of transients when powering advanced chip sets.

Quick Start Evaluation

Circuit Setup

The ISL6224EVAL board is built for easy evaluation using standard laboratory equipment. Consult Table 2 for the range of input and output voltages and currents.

Set up switch SW1 and jumpers (JP1, JP2 and JP3)

The ISL6224EVAL board is typically shipped with the jumpers installed, and SW1 set for 2.5V output enabled.

SW1 controls the ENABLE pin and three different outputs voltage. Figure 1 describes the enabling options. Table 1 shows the function of each switch position.

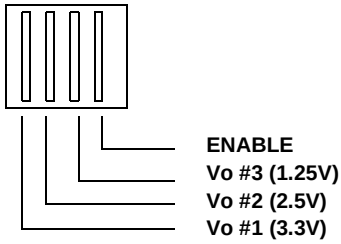


FIGURE 1. SW1 POSITION DEFINITIONS

NOTE: Only one Vo is in the UP position at any time.

TABLE 1. SWITCH S1 POSITION

SWITCH POS	SW UP/DOWN	FUNCTION
EN	UP	ENABLES ALL OTHER SW POSITIONS
EN	DOWN	ALL OUTPUTS OFF
Vo #1	UP	3.3V ON
Vo #1	DOWN	3.3V SHUTDOWN
Vo #2	UP	2.5V ON
Vo #2	DOWN	2.5V SHUTDOWN
Vo #3	UP	1.25V ON
Vo #3	DOWN	1.25V SHUTDOWN

NOTE: If All Vo #1, Vo #2 and Vo #3 switches are down, then the ouput voltage will be equal to Vref which is 0.9 V. Only one of three outputs is in UP position at a time.

JP1 determines whether the ISL6224 IC operates in hysteretic or PWM mode. If the jumper is located on the left, the IC will be in hysteretic mode. Otherwise, the IC will be in PWM mode. The evaluation board comes set for hysteretic mode.

JP2 allows the user to select the input voltage and swithching frequency operation mode. Consult Table 2 for three different operational modes. The evaluation board also shows cleary the operation mode configuration.

JP3 is used to measure the current (ICC) of the 5V power supply for the IC which measures efficiency.

TABLE 2. EVALUATION BOARD INPUT/OUTPUT REQUIREMENTS

Operation Mode	Input Voltage (V)	Output Voltage (V)	Min Output Current (A)	Typical Output Current (A)	Max Output Current (A)
Vin (300kHz)	4 to 24	0.9 to 5.5	0	2	3
Vcc (300kHz)	5	0.9 to 3.3	0	1	2
Vcc (600kHz)	5	0.9 to 3.3	0	1	2

Connect the Input Power Supply

With the input power supplies turned off, connect one power supply, which is Vin, to the VIN and GND turrets. Then connect another power supply, which is Vcc, to the 5.0V VCC and GND turrets on the left of the board.

Connect the Output Loads

Connect an electronic or other load to the output turrets on the right of the board.

Operation

Apply Power to the Board

With the Vin power supply adjusted to between 4V and 24V, and Vcc power supply adjusted to 5V, turn on the Vin power supply, then the Vcc power supply. Or turn on two of the power supplies at the same time and move the EN switcher position DOWN then UP.

Examine Start-up Waveforms

Once the enabled switcher is in the UP position, the soft-start voltage should ramp up according to its soft-start capacitor values. The output voltage should follow the soft-start voltage. The ramp-up time for the outputs may be observed on the test points provided, as well as the ramp up time on the soft-start / enable pin. Typical start-up waveforms are shown in Figure 2.

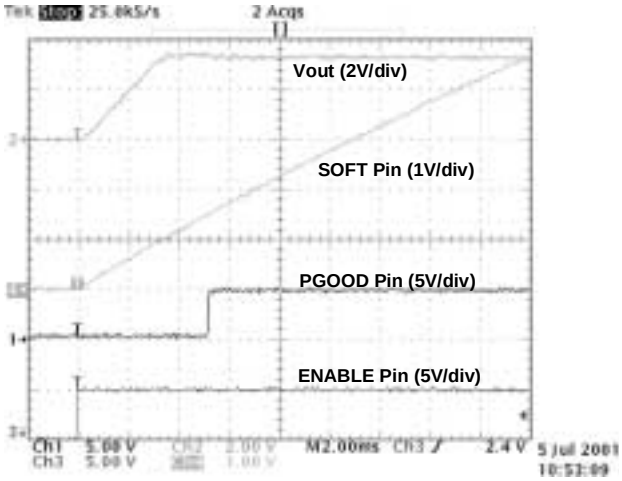


FIGURE 2. SOFT-START ON 3.3V OUTPUT (2ms/Div)

The green LED will illuminate when outputs are within 10% of their nominal value. If the EN switchers are disabled, the LED will be red, indicating the output is not within 10% of the nominal.

Output Ripple

The ISL6224 Eval Board comes with one 330 µF/6.3V SANYO POSCAP output capacitor which has 40 mili ohm ESR. Figures 3 to 9 show the output ripple and phase node at different operation modes and conditions of Vin and Fs. Please see the data sheet for details on how to select the output capacitor.

Transient Response

The response time is the time interval required to slew the inductor current from an initial current value to the load current level. The inductor ripple current affects the transient response performance. Figures 10 to 15 show the performance of evaluation board.

NOTE: In following figures; CH1: Vout = 2.5 V, AC coupled.

Evaluation Board Performance Graphs

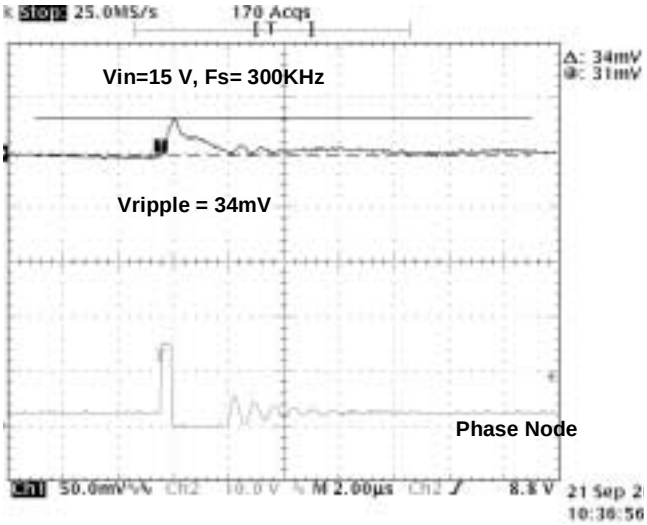


FIGURE 3. HYSTERETIC MODE AT ZERO LOAD CURRENT

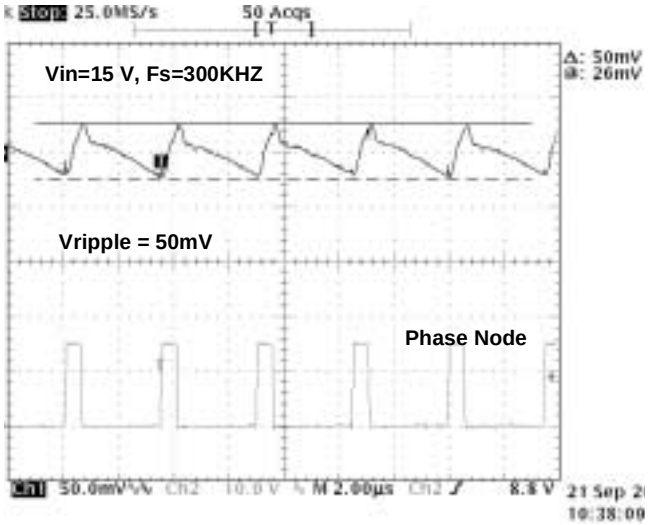


FIGURE 4. PWM MODE AT FULL LOAD CURRENT

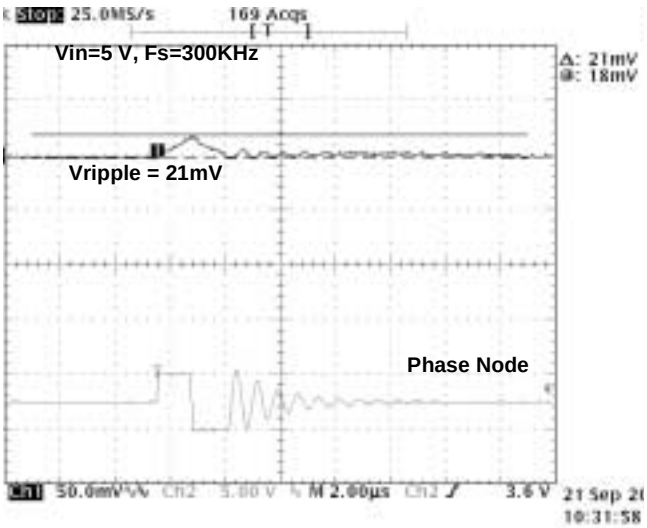


FIGURE 5. HYSTERETIC MODE AT ZERO LOAD CURRENT

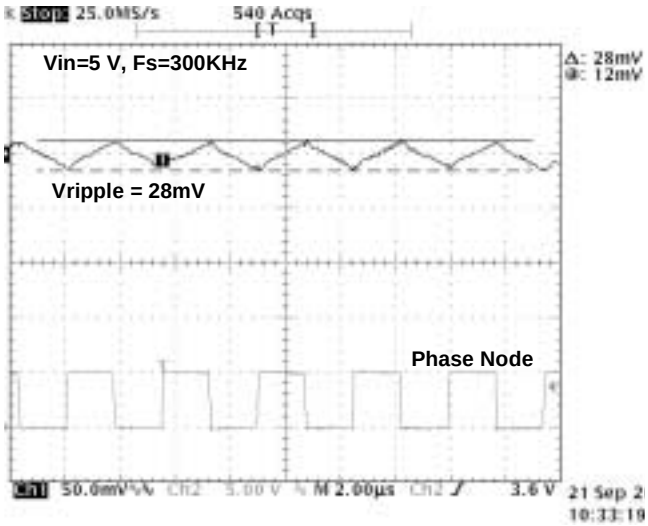


FIGURE 6. PWM MODE AT FULL LOAD CURRENT

Evaluation Board Performance Graphs (Continued)

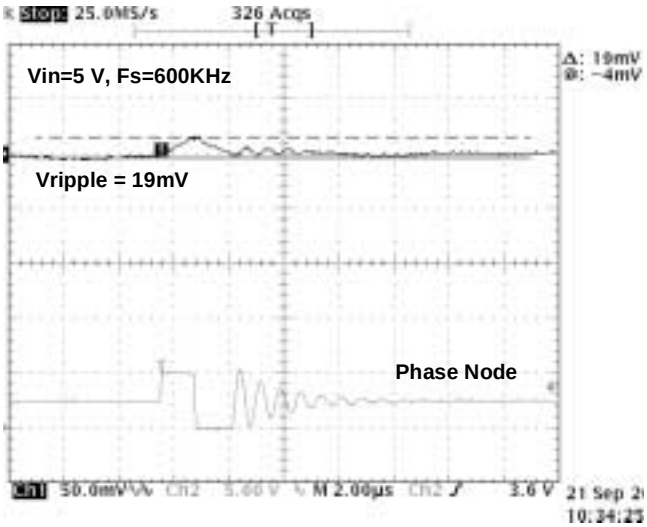


FIGURE 7. HYSTERETIC MODE AT ZERO LOAD CURRENT

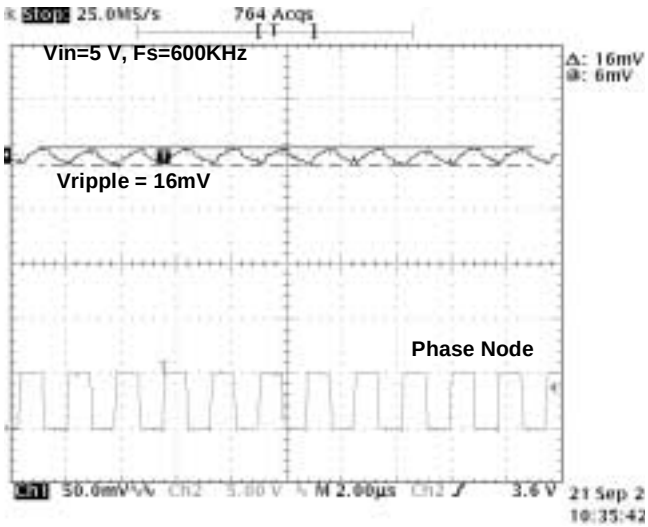


FIGURE 8. PWM MODE AT FULL LOAD CURRENT

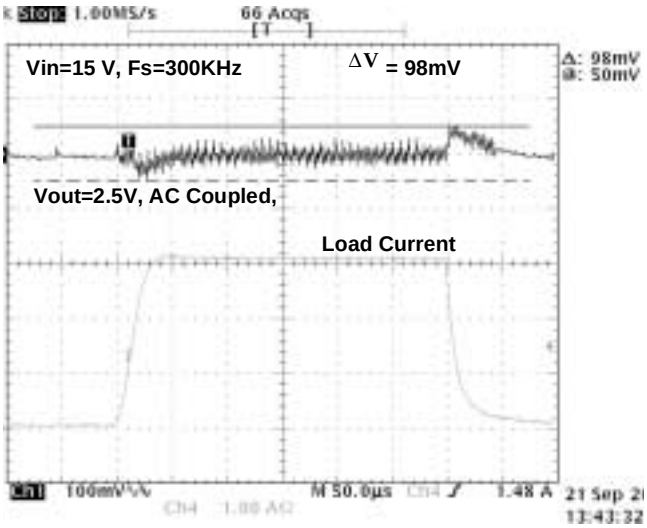


FIGURE 9. HYSTERETIC MODE TRANSIENT RESPONSE

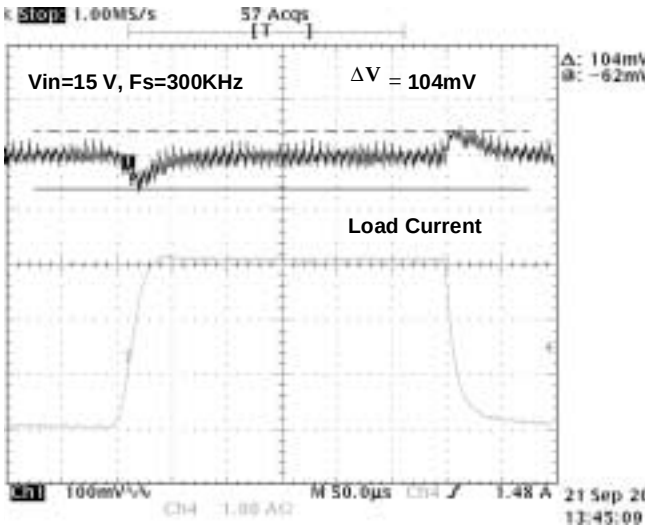


FIGURE 10. PWM MODE TRANSIENT RESPONSE

Evaluation Board Performance Graphs (Continued)

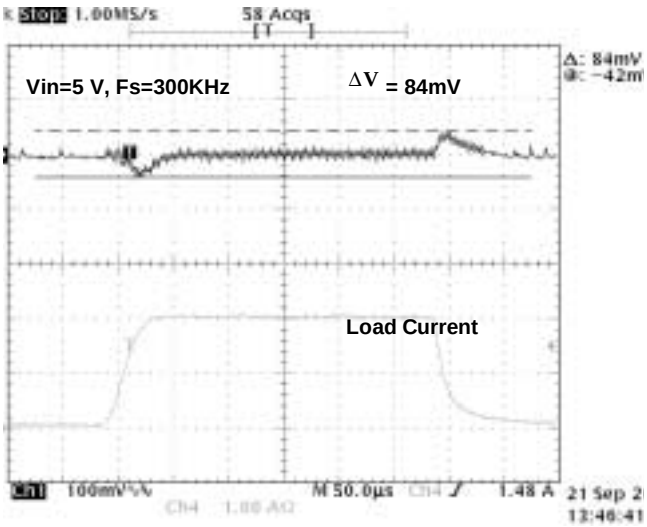


FIGURE 11. HYSTERETIC MODE TRANSIENT RESPONSE

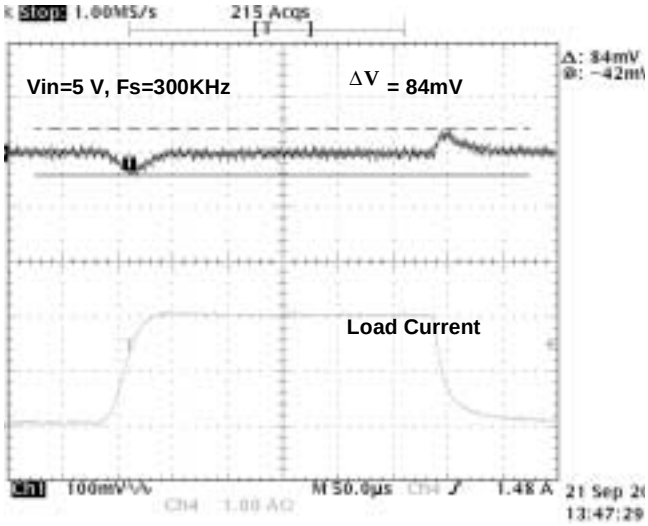


FIGURE 12. PWM MODE TRANSIENT RESPONSE

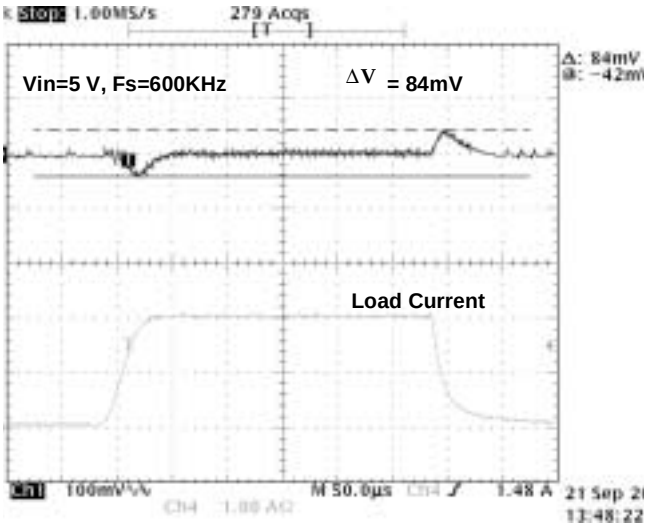


FIGURE 13. HYSTERETIC MODE TRANSIENT RESPONSE

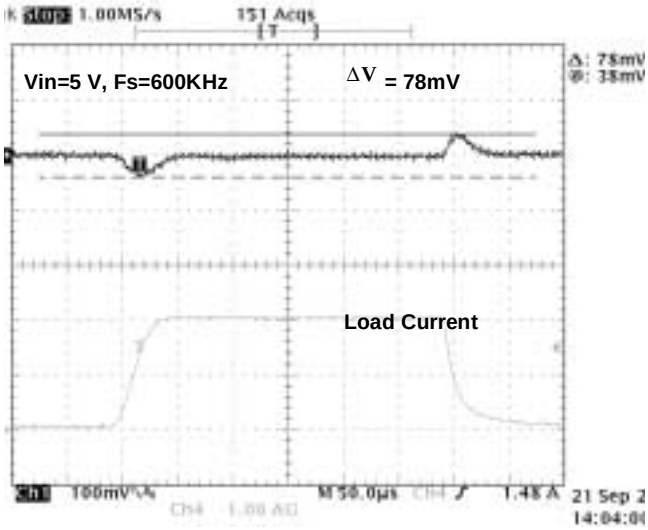


FIGURE 14. PWM MODE TRANSIENT RESPONSE

5) Over Load Shutdown

ISL6224 has an overset current pin (pin 4) which is used to set the maximum output current of the converter. There is a resistor, which connects from pin 4 to ground, to set the maximum output current. The value of this resistor can be calculated by the formula as shown in the data sheet. The evaluation board has been designed to shutdown when the load reaches 3.5A. Figure 15 shows a typical shutdown waveform when the load is over the limit. Before t0, there is a constant 3.5A load. Right after t0, the IC was shut down because the load increased above 3.5A.

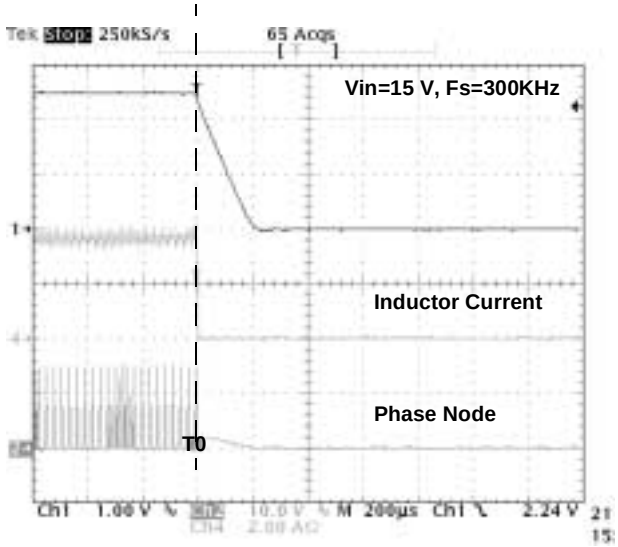


FIGURE 15. OUTPUT OVERLOAD SHUT DOWN

6) Efficiency

The ISL6224 evaluation was designed to use MOSFET's $R_{DS(ON)}$ so that efficiency is futher increased. Figures 16 to 18 show the efficiency at various output currents and input voltages.

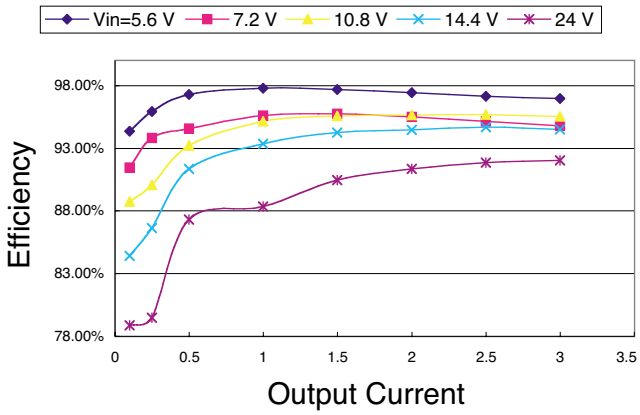


FIGURE 16. EFFICIENCY WHEN VOUT = 5V

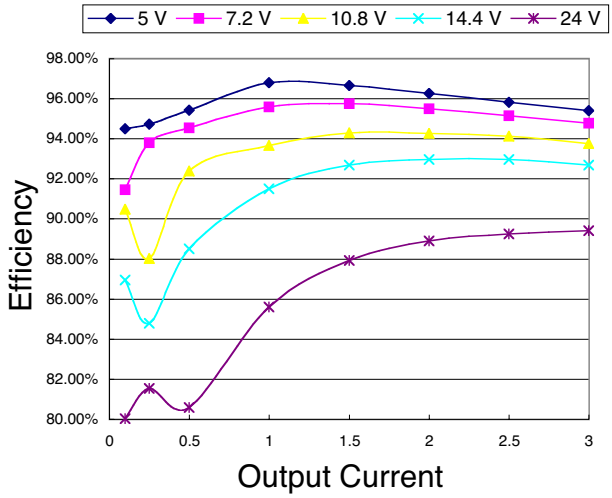


FIGURE 17. EFFICIENCY WHEN VOUT = 3.3V

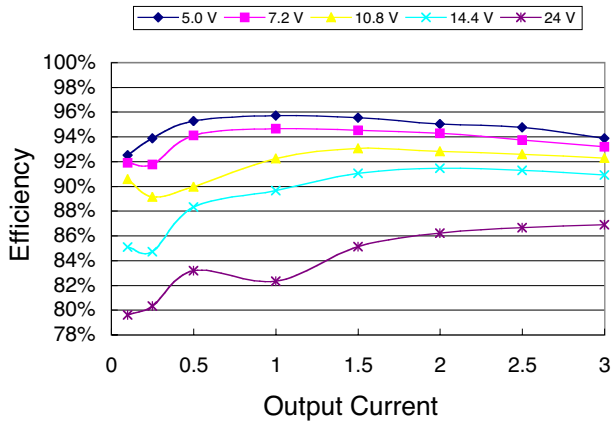


FIGURE 18. EFFICIENCY WHEN VOUT = 2.5V

7) Shutdown by Enable

When Enable Pin is low, the inductor current is instantly decreased to zero current. At same time, the output voltage is gradually decreased to zero voltage. A typical shutdown waveform is shown in Figure 19.

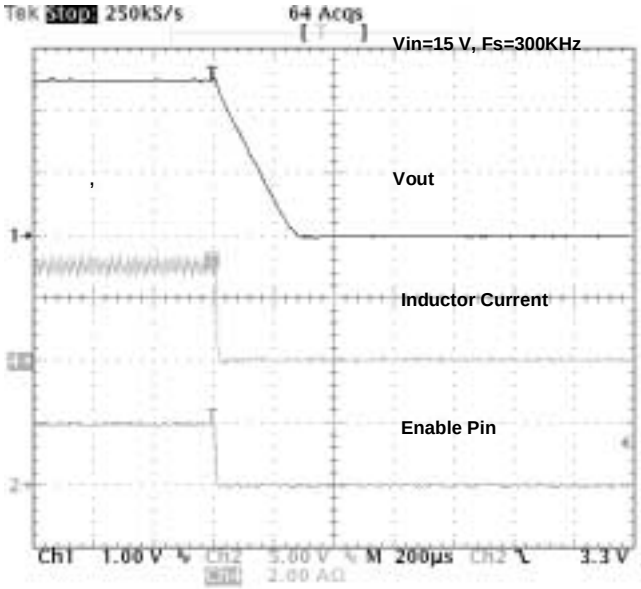


FIGURE 19. SHUT DOWN BY ENABLE PIN

8) Output Voltage Setpoint Calculation

The output voltage is set by the reference voltage and two resistors voltage divider. In the ISL6224, the reference voltage is 0.9 V. On the Eval. Board, the two resistor voltage divider network are R10 (top resistor) and bottom resistor which is R15 or R16 or R17. The equation for the setpoint is shown below.

$$Ry = \frac{R10 \times Vref}{Vo - Vref}$$

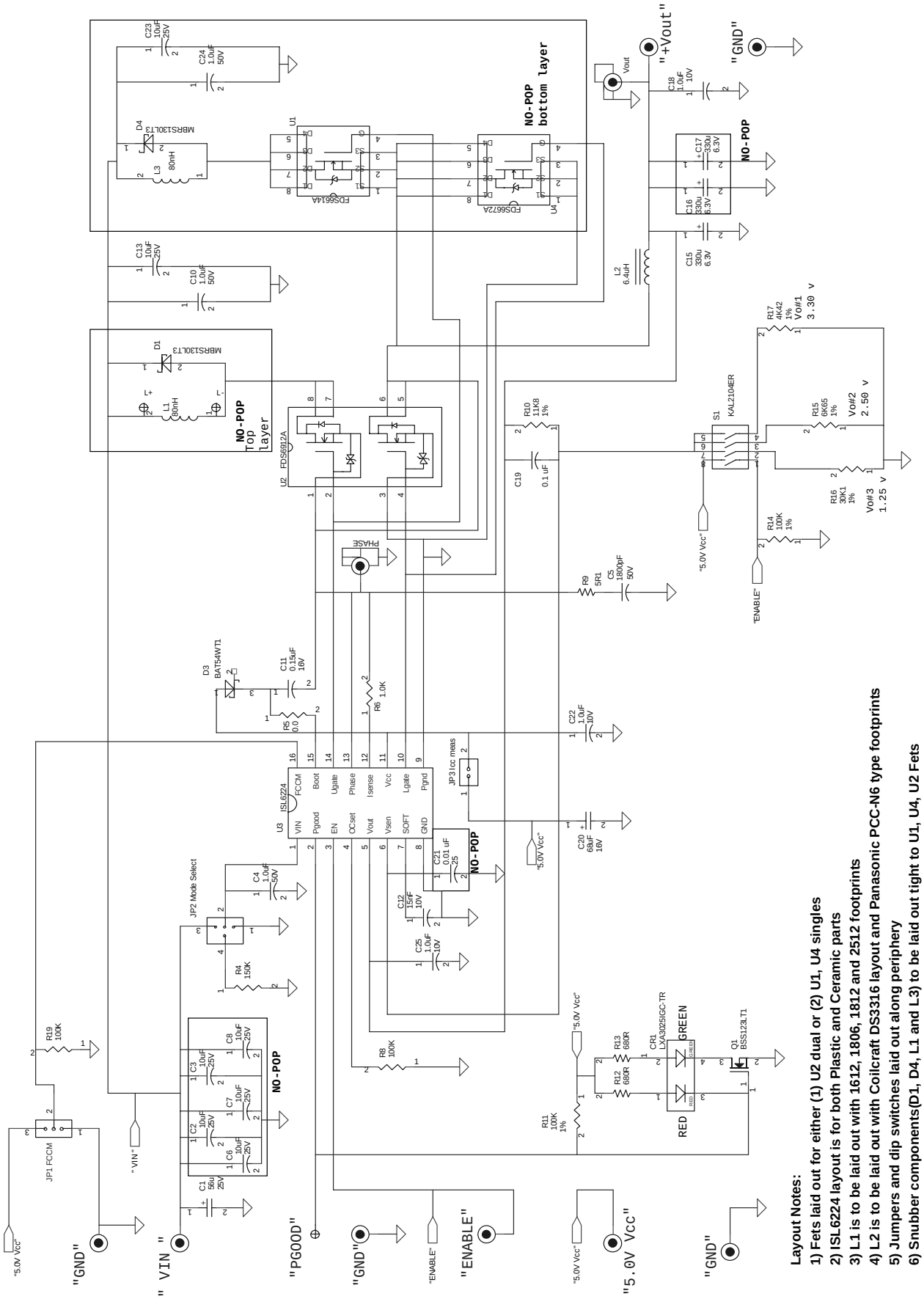
Where Ry is bottom resistor, Vo is the required output voltage and Vref is the reference voltage.

Some of the most popular output voltage setpoints are calculated in Table 3.

TABLE 3. OUTPUT VOLTAGE SETPOINT

Vo	1.25 V	1.5 V	2.5 V	3.3 V	5.0 V
R10	11.8K	11.8K	11.8K	11.8K	11.8K
Ry	30.1K	17.8K	6.65K	4.42K	2.59K

NOTE: If higher precision resistor is used, the output voltage setpoint can be more accurate.



Layout Notes:

1) Fets laid out for either (1) U2 dual or (2) U1, U4 singles
2) ISL6224 layout is for both Plastic and Ceramic parts
3) L1 is to be laid out with 1612, 1806, 1812 and 2512 footprints
4) L2 is to be laid out with Coilcraft DS3316 layout and Panasonic PCC-N6 type footprints
5) Jumpers and dip switches laid out along periphery
6) Snubber components(D1, D4, L1 and L3) to be laid out tight to U1, U4, U2 Fets
7) U1, U4, U2 Fets to be laid out tight to U3 control IC
8) Components on back: D4, L3, C23, C24, U1, U4, R21
9) No-Pop components: D1, D4, L1, C16, C17, C14, C2, C3, C6, C7, C8, U1, U4, L3, D4, C23, C24, R21

Bill of Materials

ILS6224 EVALUATION BOARD

Item	Quantity	Reference	Part	Type	Voltage
1	1	CR1	LXA3025IGC-TR		
2	1	C1	56µF	OSCON 25SP56M	25V
3	7	C2	10µF	TAIYO YUDEN TMK432BJ106MM	25V
		C3	10µF	TAIYO YUDEN TMK432BJ106MM	25V
		C6	10µF	TAIYO YUDEN TMK432BJ106MM	25V
		C7	10µF	TAIYO YUDEN TMK432BJ106MM	25V
		C8	10µF	TAIYO YUDEN TMK432BJ106MM	25V
		C13	10µF	TAIYO YUDEN TMK432BJ106MM	25V
		C23	10µF	TAIYO YUDEN TMK432BJ106MM	25V
4	3	C4	1.0µF	KEMET C1812C105K5RAC	50V
		C10	1.0µF	KEMET C1812C105K5RAC	50V
		C24	1.0µF	KEMET C1812C105K5RAC	50V
5	1	C5	1800pF	KEMET C0805C102K5RAC	50V
6	1	C11	0.15µF	KEMET C1206C154K4RAC	16V
7	1	C12	15nF	KEMET C0603C473K8RAC	10V
8	3	C15	330µF	AVX6TPB330M	
		C16	330µF	AVX6TPB330M	
		C17	330µF	AVX6TPB330M	
9	3	C18	1.0µF	KEMET C1206C105K8RAC	10V
		C22	1.0µF	KEMET C1206C105K8RAC	10V
		C25	1.0µF	KEMET C1206C105K8RAC	10V
10	1	C19	0.1µF	KEMET C0805C101K5GAC	
11	1	C20	68µF	KEMET T494D686(1)016AS	
12	1	C21	0.01µF	SAMSUNG CERAMIC CL10B221KANB	25
13	2	D4	MBRS130LT3	Motorola MBRS130LT3	
		D1	MBRS130LT3	Motorola MBRS130LT3	
14	1	D3	BAT54WT1	Motorola BAT54WT1	
15	1	JP1	Berg Header# = 68000-236	Berg Header w/ 100mil centers and (1) Berg Shunt	
16	1	JP2	Berg Header# = 68000-236	Berg 100 mil spacing Header and (1) shunt	
17	1	JP3	Berg Header#=68000-236	“Berg Header 100 mil centers, w/ (1) Berg Shunt”	
18	8	J1	1502TL-2	Keystone 1502TL-2	
		J2	1502TL-2	Keystone 1502TL-2	
		J3	1502TL-2	Keystone 1502TL-2	
		J4	1502TL-2	Keystone 1502TL-2	
		J6	1502TL-2	Keystone 1502TL-2	
		J7	1502TL-2	Keystone 1502TL-2	
		J8	1502TL-2	Keystone 1502TL-2	
		J12	1502TL-2	Keystone 1502TL-2	

ILS6224 EVALUATION BOARD (Continued)

Item	Quantity	Reference	Part	Type	Voltage
19	2	L3	80nH	NIC Components NCB1612K480TR or Spectrum Control Inc FPB1806B600P	
		L1	80nH	NIC Components NCB1612K480TR or Spectrum Control Inc FPB1806B600P	
20	1	L2	6.4µH	Panasonic ETQP6F6R4HFA	
21	1	Q1	BSS123LT1		
22	2	R8	100K	805	
		R4	150K	805	
23	1	R5	0	805	
24	1	R6	1.0K	805	
25	1	R9	5R1	1206	
26	1	R10	11K8	805	
27	3	R11	100K	805	
		R14	100K	805	
		R19	100K	805	
28	2	R12	680R	805	
		R13	680R	805	
29	1	R15	6K65	805	
30	1	R16	30K1	805	
31	1	R17	4K42	805	
32	1	S1	KAL2104ER	E-Switch KAL2104ER	
33	3	TP1	SPCJ-123-01	Jolo SPCJ-123-01	
		TP2	SPCJ-123-01	Jolo SPCJ-123-01	
		TP3	SPCJ-123-01	Jolo SPCJ-123-01	
34	1	TP4	PHASE	TEK 131-4244-00	
35	1	TP5	Vout	TEK 131-4244-00	
36	1	U1	FDS6614A	Fairchild semiconductor	
37	1	U2	FDS6912A	Fairchild semiconductor	
38	1	U3	ISL6224	Fairchild semiconductor	
39	1	U4	FDS6672A	Fairchild semiconductor	

Silk Screens

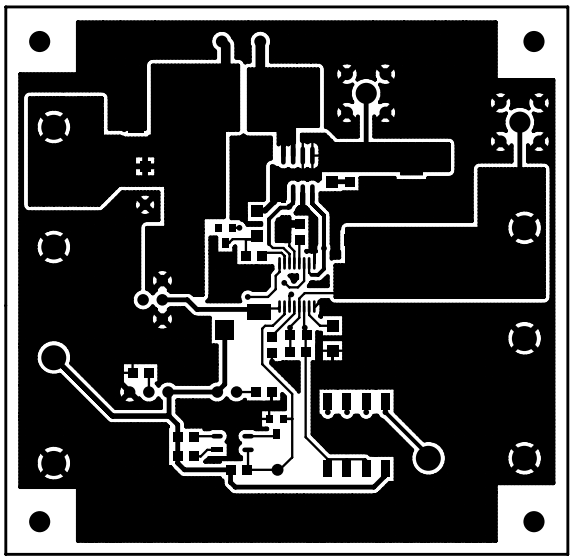


FIGURE 20. TOP LAYER

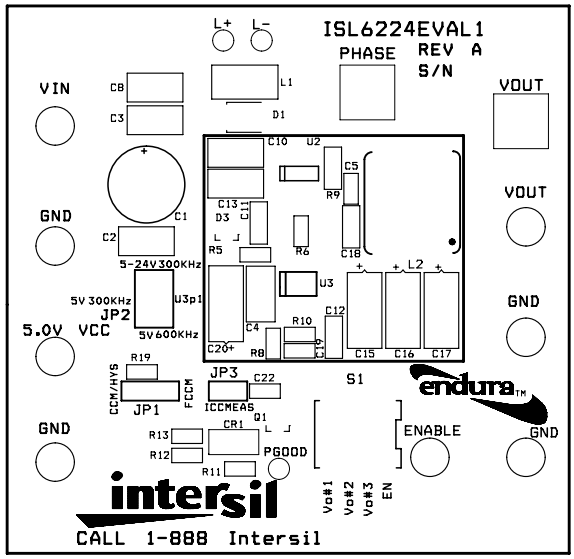


FIGURE 21. SILK SCREEN TOP

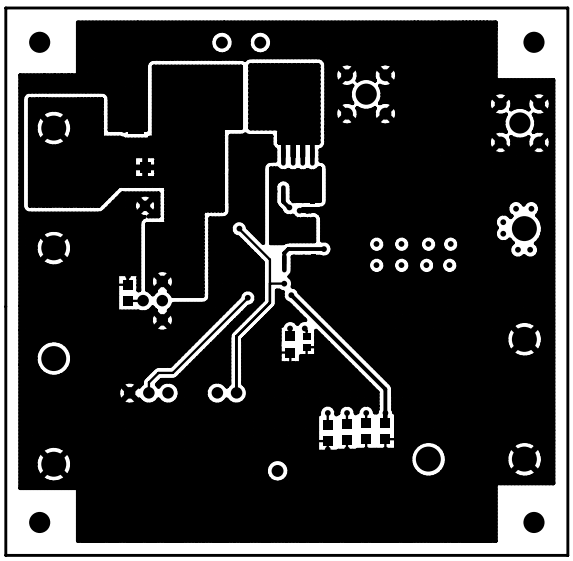


FIGURE 22. BOTTOM LAYER

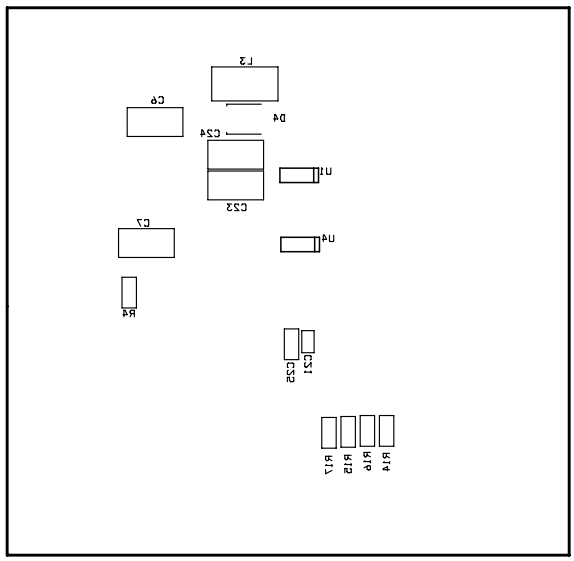


FIGURE 23. SILK SCREEN BOTTOM

Silk Screens (Continued)

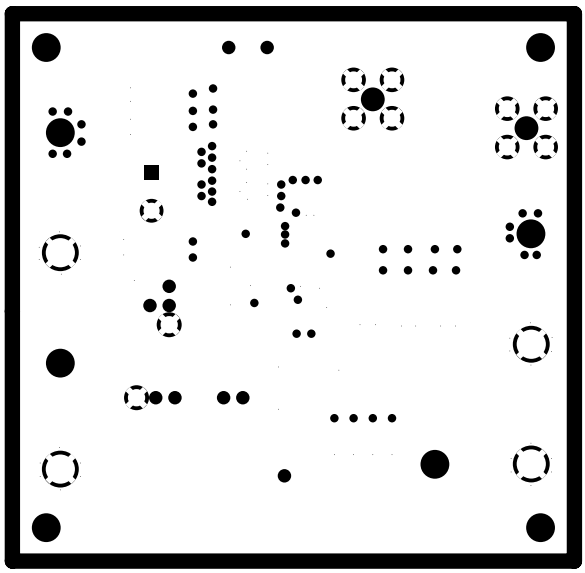


FIGURE 24. GROUND INTERNAL

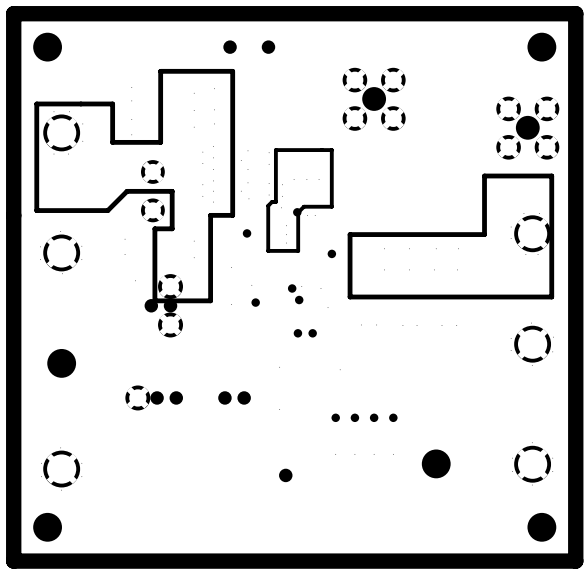


FIGURE 25. POWER INTERNAL